

Y. Kii
U.S. Serial No. 10/797,743
Page 3 of 10

Amendments to the claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of claims:

Claim 1 (currently amended): A graphic processing apparatus having a Z-buffer memory storing a Z value representing a depth of a display object when seen from a visual point per pixel and a pixel memory storing color data on each pixel for creating an image of a shadowed three-dimensional object having a shadow produced by obstructing a ray of light from a light source by the three-dimensional object, comprising:

a visual-point coordinate conversion processing section for upon input of graphic data on normal polygons constituting each object including the three-dimensional object and on shadow polygons constituting a shadow volume that defines a shadow space produced by obstructing the ~~ray~~ ray of light from the light source by the three-dimensional object, converting the graphic data to visual-point coordinates and depth values, and outputting the obtained visual-point coordinates and depth values in a state of being sorted into those of front-facing shadow polygons that face front, those of back-facing shadow polygons that face back when seen from the visual point, and those of the normal polygons; and

a hidden surface removal and shadowing processing section for obtaining a coordinate region that is positioned behind the front-facing shadow polygons and in front of the back-facing shadow polygons when seen from the visual point based on the visual-point coordinates, the depth values and the Z-buffer memory after hidden surface removal processing by Z-buffer method is performed on the normal polygons, and updating color data on pixels in the pixel memory corresponding to the obtained coordinate region to shadow color data.

Claim 2 (original): The graphic processing apparatus as defined in claim 1, wherein
the Z-buffer memory and the pixel memory have a capacity for one line in one display screen, and

Y. Kii
U.S. Serial No. 10/797,743
Page 4 of 10

the visual-point coordinate conversion processing section and the hidden surface removal and shadowing processing section process per line.

Claim 3 (original): The graphic processing apparatus as defined in claim 1, wherein if a plurality of the shadow volumes are present, the hidden surface removal and shadowing processing section performs processing concerning the shadow polygons per shadow volume.

Claim 4 (currently amended): A graphic processing apparatus having a Z-buffer memory storing a Z value representing a depth of a display object when seen from a visual point per pixel and a pixel memory storing color data on each pixel for creating an image of a shadowed three-dimensional object having shadows produced by obstructing a ray of light from a light source by the three-dimensional object, comprising:

a normal polygon conversion section for upon input of graphic data on normal polygons constituting each object including the three-dimensional object, converting the graphic data to visual-point coordinates and depth values;

a shadow polygon conversion section for upon input of graphic data on shadow polygons constituting a shadow volume that defines a shadow space produced by obstructing the ~~ray~~ ray of light from the light source by the three-dimensional object, converting the graphic data to visual-point coordinates and depth values, and outputting the visual-point coordinates and the depth values in a state of being sorted into those of front-facing shadow polygons that face front when seen from a visual point and those of back-facing shadow polygons that face back when seen from the visual point;

a normal polygon processing section for performing hidden surface removal processing by Z-buffer method on the normal polygons based on the visual-point coordinates and the depth values of the normal polygons and updating color data and a Z value of each pixel in the pixel memory and the Z-buffer memory based on the processing result;

a back-facing shadow polygon processing section for obtaining a coordinate region positioned in front of the back-facing shadow polygons when seen from the visual point based on

Y. Kii
U.S. Serial No. 10/797,743
Page 5 of 10

the visual-point coordinates and the depth values of the back-facing shadow polygons and on the Z values after the hidden surface removal processing is performed;

a shadow flag memory for storing a flag value representing a visual-point coordinate positioned in front of the back-facing shadow polygons; and

a front-facing shadow polygon processing section for obtaining a coordinate region positioned behind the front-facing shadow polygons and in front of the back-facing shadow polygons when seen from the visual point based on the visual-point coordinates and the depth values of the front-facing shadow polygons and on the Z values after the hidden surface removal processing is performed and on the flag value, and for updating color data on pixels in the pixel memory corresponding to the obtained coordinate region to shadow color data.

Claim 5 (original): The graphic processing apparatus as defined in claim 4, wherein

the Z-buffer memory, the pixel memory, and the shadow flag memory have a capacity for one line in one display screen, and

the normal polygon conversion section, the shadow polygon conversion section, the normal polygon processing section, the back-facing shadow polygon processing section, and the front-facing shadow polygon processing section process per line.

Claim 6 (original): The graphic processing apparatus as defined in claim 4, wherein

if a plurality of the shadow volumes are present, the back-facing shadow polygon processing section and the front-facing shadow polygon processing section perform processing concerning the shadow polygons per shadow volume.

Claim 7 (original): The graphic processing apparatus as defined in claim 4, wherein

the normal polygon conversion section, the shadow polygon conversion section, the normal polygon processing section, the back-facing shadow polygon processing section, and the front-facing shadow polygon processing section are included in a portable device.

Y. Kii
U.S. Serial No. 10/797,743
Page 6 of 10

Claim 8 (original): The graphic processing apparatus as defined in claim 7, wherein
the portable device is connectable to a communication network, and the graphic data is
obtained through communications via the communication network.

Claim 9 (currently amended): A graphic processing method using a Z-buffer memory storing a
Z value representing a depth of a display object when seen from a visual point per pixel and a
pixel memory storing color data on each pixel for creating an image of a shadowed three-
dimensional object having shadows produced by obstructing a ray of light from a light source by
the three-dimensional object, comprising:

- converting graphic data on normal polygons constituting each object including the three-
dimensional object to visual-point coordinates and depth values;

- converting graphic data on shadow polygons constituting a shadow volume that defines a
shadow space produced by obstructing the ~~ray~~ ray of light from the light source by the three-
dimensional object to visual-point coordinates and depth values, and sorting the visual-point
coordinates and the depth values into those of front-facing shadow polygons that face front when
seen from the visual point and those of back-facing shadow polygons that face back when seen
from the visual point;

- performing hidden surface removal processing by Z-buffer method on the normal
polygons based on the visual-point coordinates and the depth values of the normal polygons and
updating color data and a Z value of each pixel in the pixel memory and the Z-buffer memory
based on the processing result;

- obtaining a coordinate region positioned in front of the back-facing shadow polygons
when seen from the visual point based on the visual-point coordinates and the depth values of the
back-facing shadow polygons and the Z values after the hidden surface removal processing is
performed;

- obtaining a coordinate region positioned behind the front-facing shadow polygons when
seen from the visual point based on the visual-point coordinates and the depth values of the
front-facing shadow polygons and the Z values after the hidden surface removal processing is
performed; and

Y. Kii
U.S. Serial No. 10/797,743
Page 7 of 10

updating color data on pixels in the pixel memory corresponding to a coordinate region positioned behind the front-facing shadow polygons and in front of the back-facing shadow polygons when seen from the visual point to shadow color data.

Claim 10 (currently amended): ~~A~~ The graphic processing apparatus as defined in claim 4 running a graphic processing program causing a computer to function as the normal polygon conversion section, the shadow polygon conversion section, the normal polygon processing section, the back-facing shadow polygon processing section, and the front-facing shadow polygon processing section as defined in claim 4.

Claim 11 (original): A program storage medium allowing computer to read, characterized in that the graphic processing program as defined in claim 10 is stored.